

Microsemi SmartFusion Modbus Reference Design User Guide

[Home](#) » [Microsemi](#) » **Microsemi SmartFusion Modbus Reference Design User Guide**



Microsemi®
Smart Fusion Modbus Reference Design
User Guide

Contents

- 1 Introduction
 - 1.1 Overview
 - 1.2 Reference Design Features
- 2 Installing and Using the Reference Design
 - 2.1 Installing the Reference Design
 - 2.2 Board Settings
 - 2.3 Default Communication Settings
 - 2.4 Using Modpoll
 - 2.5 Read Input Registers
 - 2.6 Using Automated Solution's MiniHMI
 - 2.7 Using Other Modbus Masters
- 3 SoftConsole Firmware Project
 - 3.1 Project Layout
 - 3.2 Slave Firmware Configuration #defines
 - 3.3 Default Configuration
 - 3.4 Linker Scripts
 - 3.5 Free Modbus Configuration Options
 - 3.6 Reference Design Slave Modbus Register Map
 - 3.7 Adding New Registers
 - 3.8 Adding Support for Additional Modbus Function Codes
- 4 Libero SoC Hardware Project
 - 4.1 MSS Resources Used
 - 4.2 Adapting the Hardware Design
- 5 RS-485 Communications
- 6 References
- 7 List of Changes
 - 7.1 List of Changes
- 8 Product Support
 - 8.1 Customer Service
 - 8.2 Customer Technical Support Center
 - 8.3 Technical Support
 - 8.4 Website
 - 8.5 Contacting the Customer Technical Support Center
 - 8.6 ITAR Technical Support
- 9 Index
- 10 Documents / Resources
 - 10.1 References
- 11 Related Posts

Introduction

Overview

Modbus is a serial communications and application level protocol primarily targeting industrial network communications. The origins, rationale, and specifications for Modbus are summarized in the Modbus Organization FAQ [Reference 3], the Modbus Organization technical resources page [Reference 4], and also in various Modbus tutorials and introductory guides available on the web [Reference 9].

Reference Design Features

1. Modbus over serial line reference slave implementation based on a bare metal (non [Free]RTOS) implementation of the Free Modbus communications stack [Reference 6], targeting the Micro semi Smart Fusion™ customizable system-on-chip (choc) device [Reference 2] A2F500-DEV-KIT board 1 .

2. Supports Modbus serial line ASCII and RTU modes.
3. Supports RS-232 (point to point master and single slave) and RS-485 (bus-based multidrop master and multiple slaves) physical communication mediums.
4. Includes the complete Libero® System-on-Chip (SoC) software v10.0 SPB/MSS v2.4.105 hardware and Soft Console (v3.3) firmware projects implementing the reference design Modbus slave which can be exercised using any third party Modbus master (including those which are PC hosted, mentioned in [Reference 9]) and which can be adapted and extended for customer specific requirements.
5. Supported Modbus functions—based on the Free Modbus communications stack, the reference design supports the following Modbus functions out of the box:
 - a. Read Input Register (function code 0x04)
 - b. Read Holding Registers (0x03)
 - c. Write Single Register (0x06)
 - d. Write Multiple Registers (0x10)
 - e. Read/Write Multiple Registers (0x17)
 - f. Read Coils (0x01)
 - g. Write Single Coil (0x05)
 - h. Write Multiple Coils (0x0F)
 - i. Read Discrete Inputs (0x02)
 - j. Report Slave ID (0x11)

Refer to the Free Modbus API documentation [Reference 7] for information about extending the slave to support additional Modbus function codes.

6. Supports a variety of sample single bit read-only discrete input registers, single bit read-write coils registers, 16-bit read-only input registers and 16-bit read-write holding registers connected to board resources such as OLED (holding), LEDs (coils), DIP switches (discrete inputs), pushbuttons (discrete inputs), and ACE analog voltage channel and RTC (inputs).

The number and type of registers can be extended by the end user.

1. The reference design Libero SoC project can easily be retargeted to the Smart Fusion A2F200-EVAL-KIT board, which supports only RS-232 (via the Silicon Laboratories CP2102 USB to UART bridge) communications and which does not support all of the hardware resources available on the A2F500-DEV-KIT board that are mapped to Modbus registers in the reference design slave implementation.

Installing and Using the Reference Design

Installing the Reference Design

Download the design files from the Microsemi SoC Products Group website:
www.microsemi.com/soc/download/rsc/?f=MS_SF_Modbus_Ref_Design_DF

The reference design is delivered as a rar file and the contents should be extracted to a suitable folder on disk. Once extracted, the folder structure would be displayed as shown in Figure 1-1.

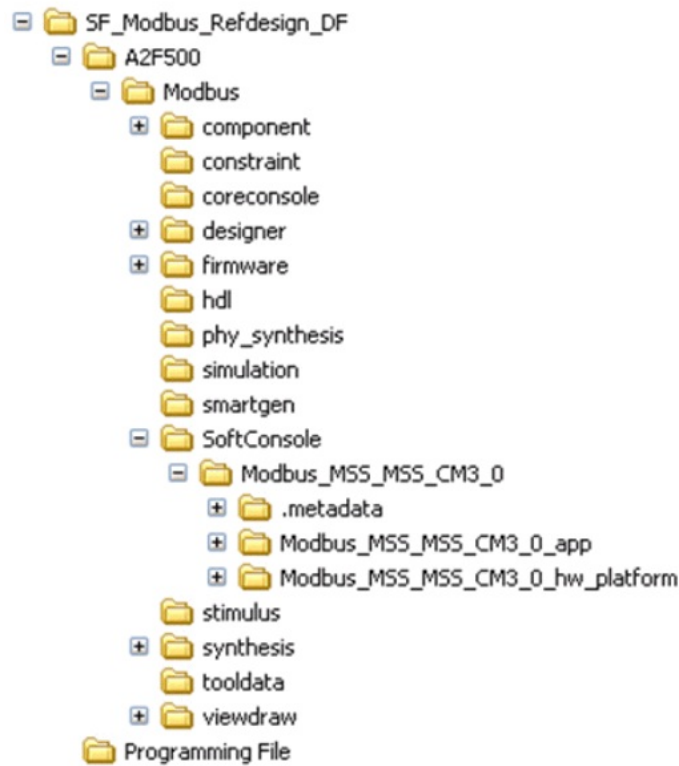


Figure 1-1 • Folder Structure

To get started with the reference design follow these steps:

1. Extract the contents of the reference design tarfile.
2. Open the hardware project `..\SF_Modbus_Refdesign_DF\A2F500\Modbus\Modbus.prj` in Libero SoC IDE v10.0.
3. If necessary, bring the design through the project flow to create an STP for programming the target A2F500-DEV-KIT board.
4. Program the resulting STP to the A2F500-DEV-KIT board using Flash Pro from within Libero Sac
5. Launch the Soft Console project and double-click Write Application Code under Develop Firmware in the Libero SoC design flow window.
6. Build the Release target. Right-click the `Modbus_MSS_MSS_CM3_0_app` and `Modbus_MSS_MSS_CM3_0_hw_platform` projects in the Soft Console Project Explorer and choose Build Configurations > Set Active > Release and then right-click again and choose Build Project.
7. Download the release build to Smart Fusion MSS Embedded NVM (ENVM). Right-click the `Modbus_MSS_MSS_CM3_0_app` project in the Soft Console Project Explorer and choose Debugs > Debug Configurations. In the Debug Configurations dialog, select the `Modbus_MSS_MSS_CM3_0_app` Debug in ENVM debug configuration and choose Debug. The release build firmware should download to ENVM, start running, and then stop at the breakpoint at `main()`.
8. Terminate the debug session and close Soft Console.
9. Power cycle the A2F500-DEV-KIT board and the firmware should run, displaying the following message on the OLED, lighting LEDs D2 and D4. Micro semi Corp v1.0 Smart Fusion Modbus

Board Settings

The design example is made to be working on Smart Fusion development kit board and Smart Fusion evaluation kit board with default board settings. Refer the following user's guides for default board settings:

- [Smart Fusion Development Kit User's Guide](#)
- [Smart Fusion Evaluation Kit User's Guide](#)

Default Communication Settings

The default communication settings are as follows:

- Modbus serial RTU mode
- Modbus slave address 0x01
- MSS UART_0/RS-232 physical layer communications (via the Smart Fusion chock board's Silicon Laboratories CP2102 USB to UART bridge)
- 19200 baud
- 8 data bits, as required by Modbus RTU mode. If the firmware is reconfigured to run in ASCII mode, the Modbus master must be configured to use 7 data bits, as required by Modbus ASCII.
- Even parity
- 1 stop bit

When connecting a Modbus master to the reference design slave, connect a USB cable from your PC to the A2F500-DEV-KIT board's MSS UART_0/Silicon Laboratories CP2102 USB to UART bridge mini USB connector and make sure that you know what port number is allocated to the virtual USB COM port before configuring the master Modbus and communication settings. If you reconfigure the firmware to use MSS UART_1/RS-485, refer to the "RS-485 Communications" section on page 27.

Using Modpoll

MoD poll ® is a simple command line read-only freeware Modbus master available from proton Pty Ltd. [Reference 9]. Download and install/extract MoD poll, open a command shell, and change directory to the folder containing the modpoll.exe executable. Modpoll.exe -h displays help about the different command line options supported.

Read Input Registers

To query the reference design slave's two 16-bit read-only input registers, which store the RTC in seconds and RV1 3.3 V pot voltage in mV, run MoD poll as follows:
modpoll.exe -m rte. -a 1 -r 1 -c 2 -t 3 -b 19200 -d 8 -p even COM4

The command line parameters are shown in Table 1-1:

Table 1-1 • Description of Command Line Parameters

Command Line Option	Description
-m rtu	Modbus serial mode.
-a 1	Modbus target slave address.
-r 1	Offset from start of the relevant Modbus register block (as determined by the -t command line option below) to start reading.
-c 2	Number of values to poll.
-t 3	Poll 16-bit read-only input registers. See Table 2-3 on page 23 for details of the reference design slave's Modbus register map.
-b	19200 Baud rate.
-p even	Even parity.
COM4	The PC virtual COM port for connecting to the A2F500-DEV-KIT board. Modify this according to your local setup.

MoD poll will continuously poll the two input registers supported by the reference design slave (RTC and RV1 pot voltage).

You should see the first register (RTC) counting up in seconds and the second one varying as you turn the RV1 pot on the A2F500-DEV-KIT board (Figure 1-2).

```

C:\WINDOWS\system32\cmd.exe
C:\dev\Sandbox\Modbus\Modpoll\win32>modpoll.exe -m rtu -a 1 -r 1 -c 2 -t 3 -b 19200 -d 8 -p even COM4

modpoll - FieldTalk(tm) Modbus(R) Polling Utility
Copyright (c) 2002-2006 FOCUS Software Engineering Pty Ltd
Visit http://www.modbusdriver.com for Modbus libraries and tools.

Protocol configuration: Modbus RTU
Slave configuration...: Address/Id = 1, start reference = 1, count = 2
Communication.....: COM4, 19200, 8, even
Data type.....: 16-bit register, input register table

Polling slave (Ctrl-C to stop) ...
[I1]: 11812
[I2]: 2559
Polling slave (Ctrl-C to stop) ...
[I1]: 11813
[I2]: 2559
Polling slave (Ctrl-C to stop) ...
[I1]: 11814
[I2]: 2456
Polling slave (Ctrl-C to stop) ...
[I1]: 11815
[I2]: 2243
Polling slave (Ctrl-C to stop) ...
[I1]: 11816
[I2]: 45
Polling slave (Ctrl-C to stop) ...
[I1]: 11817
[I2]: 45
Polling slave (Ctrl-C to stop) ...
[I1]: 11818
[I2]: 1495
Polling slave (Ctrl-C to stop) ...
[I1]: 11819
[I2]: 1951
Polling slave (Ctrl-C to stop) ...
[I1]: 11820
[I2]: 1638
Polling slave (Ctrl-C to stop) ...
[I1]: 11821
[I2]: 2559
Polling slave (Ctrl-C to stop) ...
[I1]: 11822
[I2]: 2553
Polling slave (Ctrl-C to stop) ...
^C
C:\dev\Sandbox\Modbus\Modpoll\win32>_

```

Figure 1-2 • Continuous Polling

Read Discrete Input Registers

To query the 16 single-bit read-only discrete input registers, run MoD poll again with the following command line options:

```
modpoll.exe -m rtu -a 1 -r 1 -c 16 -t 1 -b 19200 -d 8 -p even COM4
```

This time use -t 1 -c 16 to read the 16 single-bit read-only discrete inputs supported by the reference design slave. See Table 2-3 on page 23 for more information about the Modbus register map supported by the reference design slave.

As Modpoll polls the slave, toggle the A2F500-DEV-KIT board's SW1-SW5 push-buttons and A2F_DIP DIP switches to see the effect that this has on the results reported by Modpoll (Figure 1-3).

```
C:\WINDOWS\system32\cmd.exe

C:\dev\Sandbox\Modbus\Modpoll\win32>modpoll.exe -m rtu -a 1 -r 1 -c 16 -t 1 -b 1
9200 -d 8 -p even COM4

modpoll - FieldTalk(tm) Modbus(R) Polling Utility
Copyright (c) 2002-2006 FOCUS Software Engineering Pty Ltd
Visit http://www.modbusdriver.com for Modbus libraries and tools.

Protocol configuration: Modbus RTU
Slave configuration...: Address/Id = 1, start reference = 1, count = 16
Communication.....: COM4, 19200, 8, eleven
Data type.....: discrete input

Polling slave <Ctrl-C to stop> ...
[1]: 1
[2]: 1
[3]: 1
[4]: 1
[5]: 1
[6]: 0
[7]: 0
[8]: 0
[9]: 0
[10]: 0
[11]: 0
[12]: 0
[13]: 0
[14]: 0
[15]: 0
[16]: 0
Polling slave <Ctrl-C to stop> ...
[1]: 0
[2]: 1
[3]: 1
[4]: 1
[5]: 1
[6]: 0
[7]: 0
[8]: 0
[9]: 0
[10]: 0
[11]: 0
[12]: 0
[13]: 0
[14]: 0
[15]: 0
[16]: 0
Polling slave <Ctrl-C to stop> ...
[1]: 1
[2]: 0
[3]: 1
[4]: 1
[5]: 1
[6]: 0
[7]: 0
[8]: 0
[9]: 0
[10]: 0
[11]: 0
[12]: 0
[13]: 0
[14]: 0
[15]: 0
[16]: 0
Polling slave <Ctrl-C to stop> ...
[1]: 1
[2]: 1
[3]: 1
[4]: 1
[5]: 1
[6]: 0
[7]: 0
[8]: 0
[9]: 0
[10]: 0
[11]: 0
[12]: 0
[13]: 0
[14]: 0
[15]: 0
```

Figure 1-3 • Query Discrete Input Registers

Read Holding Registers

The 38 16-bit read-write holding registers contain (in their lower 8 bits) the values used to display characters in each of the OLED's 38 (2 row x 19 column) character positions. Modpoll is a read-only Modbus master, so can read but not write these. To read these registers, run Modpoll as follows:

modpoll.exe -m rtu -a 1 -r 1 -c 38 -t 4:hex -1 -b 19200 -d 8 -p even COM4 In this case, -c 38 tells Modpoll to read 38 registers, -t 4:hex tells it to read the holding registers and display them in hex, and -1 tells it to poll once rather than continuously (Figure 1-4).


```
C:\WINDOWS\system32\cmd.exe

C:\dev\Sandbox\Modbus\Modpoll\win32>modpoll.exe -m rtu -a 1 -r 1 -c 38 -t 4:hex
-1 -b 19200 -d 8 -p even COM4

modpoll - FieldTalk(tm) Modbus(R) Polling Utility
Copyright (c) 2002-2006 FOCUS Software Engineering Pty Ltd
Visit http://www.modbusdriver.com for Modbus libraries and tools.

Protocol configuration: Modbus RTU
Slave configuration...: Address/Id = 1, start reference = 1, count = 38
Communication.....: COM4, 19200, 8, 1even
Data type.....: 16-bit register <hex>, output <holding> register table

Polling slave ...
[1]: 0x004D
[2]: 0x0069
[3]: 0x0063
[4]: 0x0072
[5]: 0x006F
[6]: 0x0073
[7]: 0x0065
[8]: 0x006D
[9]: 0x0069
[10]: 0x0020
[11]: 0x0043
[12]: 0x006F
[13]: 0x0072
[14]: 0x0070
[15]: 0x0020
[16]: 0x0076
[17]: 0x0031
[18]: 0x002E
[19]: 0x0030
[20]: 0x0053
[21]: 0x006D
[22]: 0x0061
[23]: 0x0072
[24]: 0x0074
[25]: 0x0046
[26]: 0x0075
[27]: 0x0073
[28]: 0x0069
[29]: 0x006F
[30]: 0x006E
[31]: 0x0020
[32]: 0x004D
[33]: 0x006F
[34]: 0x0064
[35]: 0x0062
[36]: 0x0075
[37]: 0x0073
[38]: 0x0020

C:\dev\Sandbox\Modbus\Modpoll\win32>
```

Figure 1-4 • Hex Display

Read Coils Registers

To read eight 1-bit read-write coils registers (four of which are connected to the A2F500-DEV-KIT board's LEDs), run MoD poll as follows:

```
modpoll.exe -m rtu -a 1 -r 1 -c 8 -t 0 -1 -b 19200 -d 8 -p even COM4
```

Note that the LEDs are active low, so a 0 means that the LED is on while 1 means that it is off (Figure 1-5).

```
C:\WINDOWS\system32\cmd.exe

C:\dev\Sandbox\Modbus\Modpoll\win32>modpoll.exe -m rtu -a 1 -r 1 -c 8 -t 0 -1 -b
19200 -d 8 -p even COM4

modpoll - FieldTalk(tm) Modbus(R) Polling Utility
Copyright (c) 2002-2006 FOCUS Software Engineering Pty Ltd
Visit http://www.modbusdriver.com for Modbus libraries and tools.

Protocol configuration: Modbus RTU
Slave configuration...: Address/Id = 1, start reference = 1, count = 8
Communication.....: COM4, 19200, 8, 1even
Data type.....: discrete output (coil)

Polling slave ...
[1]: 1
[2]: 0
[3]: 1
[4]: 0
[5]: 0
[6]: 0
[7]: 0
[8]: 0

C:\dev\Sandbox\Modbus\Modpoll\win32>
```

Figure 1-5 • Read Coils Registers

Using Automated Solution's MiniHMI

Automated Solutions Inc. [Reference 9] provides commercial software solutions for HMI and SCADA developers, including various Modbus solutions. Their product range includes a Modbus RTU/ASCII Master ActiveX Control and some example applications. Contact Automated Solutions Inc. or refer to their website for details about their commercial tools offerings and prices. Automated Solutions Inc. also provides a free, full featured 30-day trial version of their Modbus RTU/ASCII Master ActiveX Control and example applications which can be used to exercise and

demonstrate the features of the Microsemi Smart Fusion Modbus reference design slave.

Obtain and install the demo or full version of the Automated Solutions Inc. Modbus RTU/ASCII Master ActiveX Control package. Refer to the documentation and help provided with the package and on the Automated Solutions Inc. website for more details about the capabilities of the ActiveX component and example applications. The Mini HMI example application can be run from Start > All Programs > Automated Solutions ActiveX > Modbus Master > Mini HMI Example Application.

Read Input Registers

Run the Mini HMI example application. Click the Read Registers tab. Ensure that the Communications settings are configured appropriately to match your slave setup. See the "Default Communication Settings" section on page 8 for the default settings. The Mini HMI settings with the possible exception of Communications Port match the reference design slave default settings. Select the Modbus > Function > Input Registers radio button and in the Quantity field enter 2. Check the Auto Poll check box and Mini HMI should start, continuously polling the RTC and RV1 3.3 V pot input registers. The values of the registers should update as time passes and you rotate the RV1 pot. Clear the Auto Poll check box to stop continuous polling.

MiniHMI Example Application for Automated Solutions' Modbus Master ActiveX Control

[Welcome](#)
[Read Registers](#)
[Write Registers](#)
[Read Discretes](#)
[Write Discretes](#)
[Read/Write 4X Registers](#)
[Dialer](#)

☐ Auto Poll ☒ Poll Rate mSec

Modbus
 Function ☐ Output Registers ☒ Input Registers ☐ General Reference ☐ Scattered ☐ Report Slave ID
 Address Quantity
 Address Quantity

Data Format Address Type

Communications
 Port # Settings Timeout NodeID
 Mode: ☒ RTU ☐ ASCII
 Result Errors Polls

	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
30001	17808	45								
30011										
30021										
30031										
30041										
30051										
30061										
30071										
30081										
30091										
30101										
30111										

Successful transaction!

Figure 1-6 • Polling with Mini HMI

Read/Write Holding Registers

On the Read Registers tab, select the Modbus > Function > Output Registers radio button. Enter 38 in the Quantity field. Click the Sync Read button and Mini HMI should read back the 38 OLED character position holding registers.

MiniHMI Example Application for Automated Solutions' Modbus Master ActiveX Control

Welcome **Read Registers** **Write Registers** **Read Discretes** **Write Discretes** **Read/Write 4X Registers** **Dialer**

Async Read **Sync Read**

Auto Poll ☐ Poll Rate mSec

Modbus

Function **Address** **Quantity**

☒ Output Registers

☐ Input Registers

☐ General Reference

☐ Scattered

☐ Report Slave ID

Data Format **Address Type**

Communications

Port # **Settings** **Timeout** **NodeID**

Mode: ☒ RTU ☐ ASCII

Result **Errors** **Polls**

Successful transaction!

	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
40001	77	105	99	114	111	115	101	109	105	32
40011	67	111	114	112	32	118	49	46	48	83
40021	109	97	114	116	70	117	115	105	111	110
40031	32	77	111	100	98	117	115	32		
40041										
40051										
40061										
40071										
40081										
40091										
40101										
40111										

Figure 1-7 • Read Holding Registers

To write to the holding registers in order to change what is displayed on the OLED, go to the Write Registers tab. Ensure that the Communications settings are configured correctly ("Default Communication Settings" section on page 8). Note that the Communications settings must be set independently on each tab and are not retained between runs.

Select the Modbus > Function > Multiple Out Regs radio button and enter a value between 1 and 38 in the Quantity field. In the register grid/spreadsheet view, enter as many values as you want to write to the OLED holding registers. All 16 bits of the values will be stored but only the lower 8 bits will be written to the OLED. Click the Sync Write button to flush the new values to the reference design Modbus slave. For example, to write 7's to all OLED character positions, do the following:

MiniHMI Example Application for Automated Solutions' Modbus Master ActiveX Control

[Welcome](#)
[Read Registers](#)
[Write Registers](#)
[Read Discretes](#)
[Write Discretes](#)
[Read/Write 4X Registers](#)
[Dialer](#)

Modbus

Function: ☐ Multiple Out Regs ☐ Single Out Reg ☐ General Ref. ☐ Mask Write 4X

Address: 40001 Quantity: 38

Data Format: Integer Address Type: Modicon 5 Digit (1)

Communications

Port #: 4 Settings: 19200,E,8,1 Timeout: 500 NodeID: 1

Mode: ☒ RTU ☐ ASCII

Result: 0 Errors: 0 Polls: 1

	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
40001	55	55	55	55	55	55	55	55	55	55
40011	55	55	55	55	55	55	55	55	55	55
40021	55	55	55	55	55	55	55	55	55	55
40031	55	55	55	55	55	55	55	55		
40041										
40051										
40061										
40071										
40081										
40091										
40101										
40111										

Successful transaction!

Figure 1-8 • Write to OLED Registers

Read Discrete Inputs and Coils

To read the discrete inputs and coils, go to the Read Discrete tab. Ensure the Communications settings are set correctly, choose to read 8 or fewer coils or 16 or fewer discrete inputs and then click Sync Read to read once or Auto Poll to poll continuously. When reading the 16 discrete inputs, the Mini HMI GUI's State view will reflect changes due to manual toggling of the A2F500-DEV-KIT board's SW1-5 pushbuttons or A2F_DIPS DIP switches.

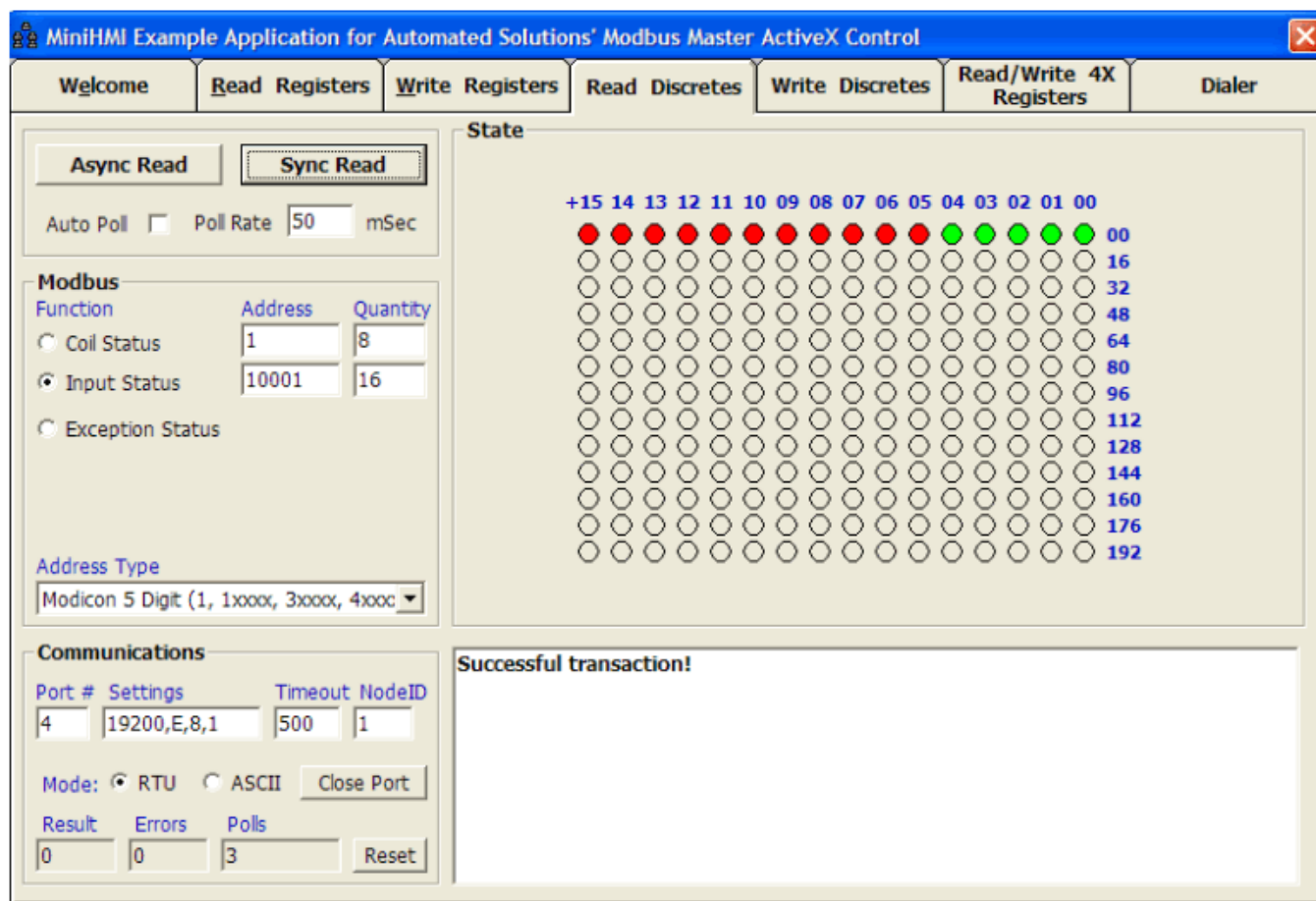


Figure 1-9 • Read Discrete Inputs and Coils

Write Coils

To write the coils (LEDs), go to the Write Discrete tab. Ensure that the Communications settings are configured appropriately. Select Single Coils or Multiple Coils and enter a Quantity between 1 and 4 (or up to 8 but only coils 1-4 are actually connected to board resources/LEDs by default). Toggle any of the first four coils (00-04) in the State view and then click the Sync Write button to change the status of the LEDs. You should see the changes reflected on the A2F-DEV-KIT board itself.

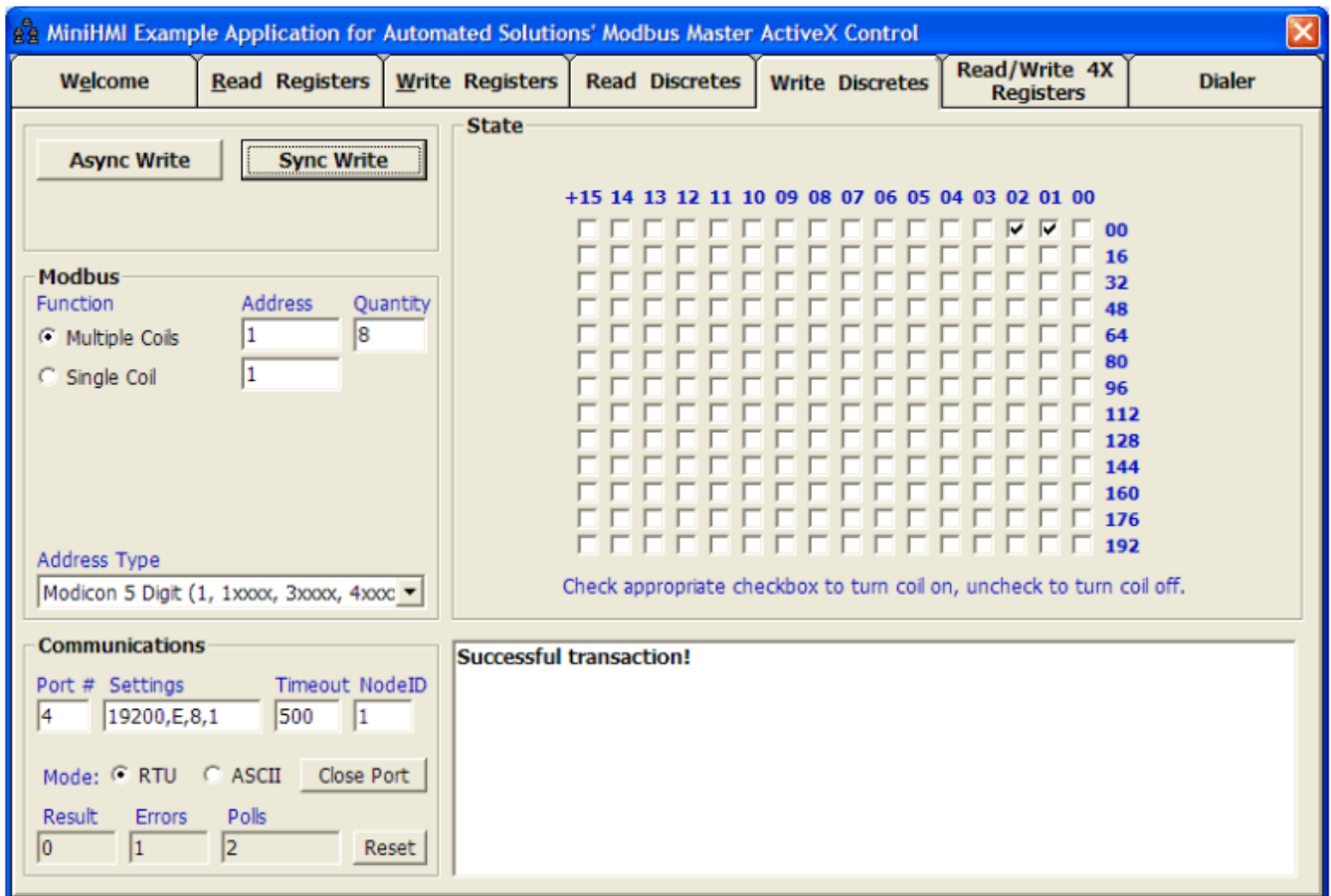


Figure 1-10 • Write Coils

Using Other Modbus Masters

Similar to the way proton Pty Ltd MoD poll and the Automated Solutions Inc. Modbus RTU/ASCII ActiveX Component Mini HMI example application can be used to interact with the Microsemi Smart Fusion Reference Design sample Modbus slave, any other Modbus compatible PC hosted or other master can also be used. The main issue is that the master Modbus and serial communications settings match the slave target settings.

SoftConsole Firmware Project

Project Layout

The screenshot of the Soft Console v3.3 Project Explorer in Figure 2-1 outlines the structure of the firmware project. To invoke SoftConsole project, double-click Write Application Code under Develop Firmware in the Libero SoC design flow window.

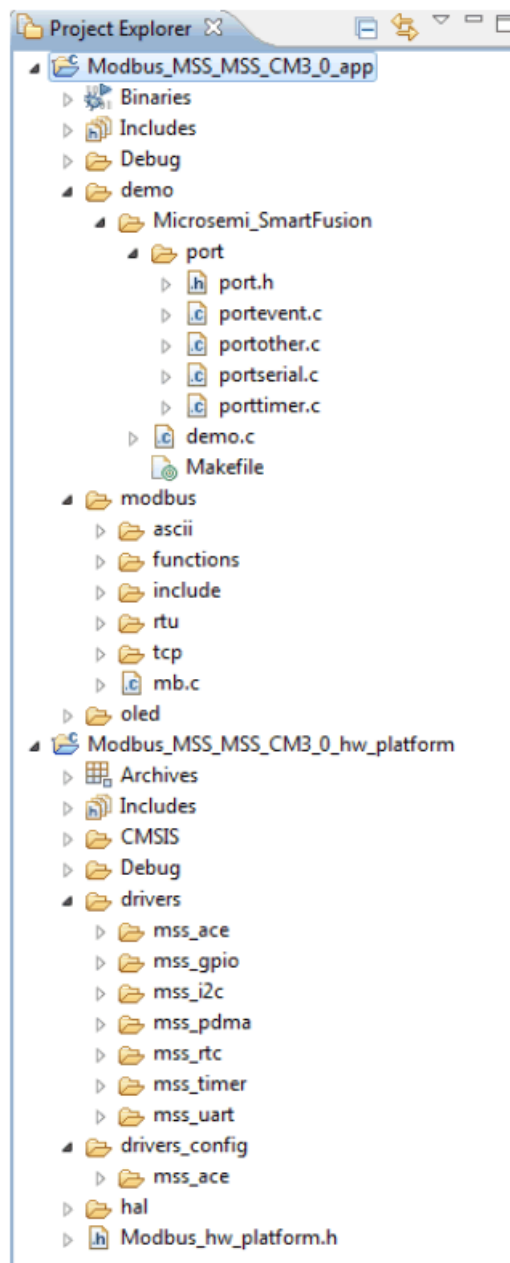


Figure 2-1 • Soft Console Project Explorer

Table 2-1 summarizes the contents and purpose of each folder:

Table 2-1 • Folder Description

Folder/File	Description
Includes	Project level include files/folders
CMSIS	Smart Fusion CMSIS-PAL
demo/Microsemi Smart Fusion/port	Free Modbus porting layer files targeting Smart Fusion chock device
demo/Microsemi Smart Fusion/demo's	Reference design slave implementation program file containing main(), default slave firmware configuration #defines, Modbus register and callback implemen tations etc.
drivers	Various Smart Fusion firmware drivers
drivers/mess ace	Smart Fusion MSS ACE Driver
drivers/mss_gpio	Smart Fusion MSS GPIO Driver
drivers/mss i2c	Smart Fusion MSS 12C Driver
drivers/mastic	Smart Fusion MSS RTC Driver
drivers/mss timer	Smart Fusion MSS Timer Driver
drivers/mss quart	Smart Fusion MSS UART Driver
drivers config/mss ace	MSS ACE driver configuration code generated from the Smart Fusion MSS configurator based on the MSS ACE configuration
Modbus	The core Free Modbus communication stack
ogled	MSS I2C based OLED driver for Smart Fusion development/eval boards

Slave Firmware Configuration #defines

The following manifest constants control various aspects of the firmware operation and can be modified by specifying new values in the Soft Console project properties (Properties > C/C++ Build > Settings > GNU C Compiler > Symbols) or by editing the #defines directly before recompiling the firmware, in Modbus_MSS_MSS_CM3_0_app/Microsemi Smart Fusion/demo's.

Table 2-2 • Manifest Constants

Manifest Constant	Description – Default Value
MODBUS_SERIAL_MODE	Free Modbus communication stack mode of serial operation <ul style="list-style-type: none"> • MB_RTU– RTU mode • MB_ASCII – ASCII mode • Default: MB_RTU Note that in RTU/ASCII mode the Modbus master serial communications must be configured for 8/7 data bits respectively
MODBUS_SLAVE_ADDR	Modbus slave address. <ul style="list-style-type: none"> • 1 – 247 (0x01 – 0xF7) • Default: 1 (0x01)

MODBUS_PORT	Serial port used <ul style="list-style-type: none"> • 0 = MSS UART_0/RS-232 • 1 = MSS UART_1/RS-485* • Default: 0
MODBUS_BAUD_RATE	Baud rate <ul style="list-style-type: none"> • Default: 19200
MODBUS_PARITY	Parity <ul style="list-style-type: none"> • MB_PAR_EVEN • MB_PAR_ODD • MB_PAR_NONE • Default: MB_PAR_EVEN
MODBUS_SLAVEID	Modbus slave id; one byte ID followed by an optional number of bytes of device specific data <ul style="list-style-type: none"> • Default: 0x55 0xC0 0xFF 0xEE
REG_DISCRETE_START	Offset (from Modbus register address 10000) of first discrete input register implemented <ul style="list-style-type: none"> • Default: 1
REG_DISCRETE_NREGS	Number of discrete input registers implemented <ul style="list-style-type: none"> • Default: 2
REG_COILS_START	Offset (from Modbus register address 0) of first coil register implemented <ul style="list-style-type: none"> • Default: 1
REG_COILS_NREGS	Number of discrete input registers implemented <ul style="list-style-type: none"> • Default: 1
REG_INPUT_START	Offset (from Modbus register address 30000) of first input register implemented <ul style="list-style-type: none"> • Default: 1
REG_INPUT_NREGS	Number of input registers implemented <ul style="list-style-type: none"> • Default: 2
REG_HOLDING_START	Offset (from Modbus register address 40000) of first holding register implemented <ul style="list-style-type: none"> • Default: 1
REG_HOLDING_NREGS	Number of holding registers implemented <ul style="list-style-type: none"> • Default: 38

Note: *A2F500-DEV-KIT only – not supported on A2F200-EVAL-KIT

Default Configuration

By default, the reference design Soft Console firmware project is configured to use the following Modbus and

serial settings:

- Modbus serial RTU mode
- Modbus slave address 0x01
- Modbus slave id 0x55 with three optional data bytes 0xC0 0xFF 0xEE
- MSS UART_0/RS-232 physical layer communications (via the Smart Fusion board's Silicon Laboratories CP2102 USB to UART bridge)
- 19200 baud
- 8 data bits (as required by Modbus RTU mode; Modbus ASCII mode uses 7 data bits)
- Even parity
- 1 stop bit

Linker Scripts

By default, the project is set up to use the following CMSIS-PAL sample linker scripts:

- Debug target: Modbus_MSS_MSS_CM3_0_hw_platform/CMSIS/startup_gcc/debug-in-actelsmartfusionesram.ld
- Release target: Modbus_MSS_MSS_CM3_0_hw_platform/CMSIS/startup_gcc/debug-in-actelsmartfusionenvm.ld

The debug target supports downloading to and debugging from Smart Fusion MSS Embedded SRAM (ESRAM). The release target supports downloading to and debugging from Smart Fusion MSS Embedded NVM (ENVN). Once the release target has been downloaded, it will persist in NVM and will run from the board reset/power cycle. If you prefer to download the firmware via Flash Pro, the release target can be modified to use the CMSIS CMSIS/startup_gcc/production-execute-in-place. Id linker script and the Intel HEX file resulting from the build process can be imported into an MSS ENVN Data Storage Client configured to load at offset 0x00000000 of ENVN so that the firmware runs from ENVN out of reset.

As with any Smart Fusion firmware project, other build/link and memory configurations are possible, such as booting from ENVN, copying/relocating to ESRAM or external RAM and continuing to run from there, or more sophisticated “scatter loading” of portions of the firmware image to disparate memory regions. These configurations are beyond the scope of this document.

Free Modbus Configuration Options

See the Free Modbus API documentation [Reference 7] for information about manifest constants (in Smart Fusion demo/Modbus/include/mbconfig.h) that control the configuration of the Free Modbus communications stack itself.

Reference Design Slave Modbus Register Map

The reference design slave firmware supports the Modbus registers shown in Table 2-3 1.

Table 2-3 • Supported Modbus Registers

Modbus Address	Physical Resource
Coils Registers – Single Bit Read/Write	
1	LED D1

2	LED D2
3	LED D3
4	LED D4
5	Not connected – reads as 0, writes ignored
6	Not connected – reads as 0, writes ignored
7	Not connected – reads as 0, writes ignored
8	Not connected – reads as 0, writes ignored
Discrete Input Registers – Single Bit Read Only	
10001	Push-button SW1
10002	Push-Button SW2
10003	Push-button SW3
10004	Push-button SW4
10005	Push-button SW5
10006	Not connected – reads as 0
10007	Not connected – reads as 0
10008	Not connected – reads as 0
10009	DIP switch A2F_DIP 1
10010	DIP switch A2F_DIP 2
10011	DIP switch A2F_DIP 3
10012	DIP switch A2F_DIP 4
10013	Not connected – reads as 0
10014	Not connected – reads as 0
10015	Not connected – reads as 0
10016	Not connected – reads as 0
Input Registers – 16-Bit Read Only	
30001	RTC value in seconds (0 to 65535)

30002	ACE RV1 3.3 V pot voltage in mV
Holding Registers – 16-Bit Read/Write	
40001 ... 40038	OLED (2 line ×19 character) positions 1 .. 38 (only lower 8 bits of 16bit value displayed but full 16 bits stored internally and read back)

1. Note that when retargeting the reference design to the Smart Fusion A2F200-EVAL-KIT board, some of the board resources mapped to Modbus registers are not available or the relevant chip-level I/O signals are connected to other resources. For example, the A2F200-EVAL-KIT board only has push-buttons SW1 and SW2 available for customer use and does not have the A2F_DIP DIP switches at all.

Adding New Registers

New registers can be added by redefining the relevant REG_<Modbus-register class>_NREGS configuration manifest constant where <Modbus-register-class> is one of DISCRETE, COILS, INPUT or HOLDING. Once defined, the slave allocates sufficient buffer memory for storing the registers.

Connecting these registers up to hardware board resources requires the modification of the relevant Free Modbus register access handler callback function eMBRegDiscrete(), emberCoils(), eMBRegInputCB(), or emberHoldings() as well as the possible modification of the Libero SoC hardware project to support the necessary hardware resources.

Adding Support for Additional Modbus Function Codes

By default, the reference design slave provides support for the following Modbus function codes:

- Read Input Register (function code 0x04)
- Read Holding Registers (0x03)
- Write Single Register (0x06)
- Write Multiple Registers (0x10)
- Read/Write Multiple Registers (0x17)
- Read Coils (0x01)
- Write Single Coil (0x05)
- Write Multiple Coils (0x0F)
- Read Discrete Inputs (0x02)
- Report Slave ID (0x11)

See the Free Modbus API documentation [Reference 7] for information about adding support for other Modbus functions by adding callbacks to handle the relevant function codes.

Libero SoC Hardware Project

A Libero SoC v10.0 SPB project using the Smart Fusion MSS v2.5.106 microcontroller subsystem (MSS) is provided which implements the hardware design on which the reference design slave firmware runs.

MSS Resources Used

The reference design Libero SoC hardware project uses the following Smart Fusion MSS resources by default:

1. Clock configuration: all clocks (FCLK, ACLK, PCLK0, PCLK1) are 50 MHz, derived from the 100 MHz on-chip RC oscillator.
2. Serial communications: UART_0 for RS-232 and UART_1 for RS-485 communications on the A2F500-DEV-KIT board.
3. Timers:
 - Timer 1: Used to generate a 50 μ s timer interrupt required by Free Modbus for Modbus protocol timing.
 - Timer 2: Used in UART_1/RS-485 communications mode to implement an 8 ms delay for MAXIM MAX3430 RS-485 transceiver transmit/receive turnaround timing and to allow for appropriate settling time when toggling the transceiver's drive enable/receive enable – DE/REn signals. If RS-485 mode is not being used, MSS Timer 2 is freed up for other use. In addition to the resources above required for the core Modbus functionality, the following resources are used to implement the demo program and reference design slave Modbus registers:
4. ARM® Cortex™-M3 Sys Tick: Used by the demo program to generate a 100 ms timer interrupt, from which the ISR is used to synchronize board hardware resources and reference design slave Modbus registers.
5. ACE: Used to implement the RV1 3.3 V pot Modbus input register.
6. RTC: Used to implement the RTC Modbus register.
7. I2C_0: Used to interface to the OLED display for displaying the reference design slave holding registers.
8. GPIOs: Used to interface to LEDs (x4), push-buttons (x5) and DIP switches (x4), which are used to implement the reference design slave Modbus discrete input and coil registers.

Adapting the Hardware Design

For the most part, the only changes that might need to be made to the hardware design are those required in order to map additional hardware resources to Modbus slave registers. The reference design slave comes with a set of illustrative Modbus registers mapped to specific hardware board resources.

RS-485 Communications

By default, the reference design firmware Soft Console project is configured to use MSS UART_0/RS-232 communications. To use MSS UART_1/RS-485 communications on the A2F500-DEV-KIT board, the firmware can easily be reconfigured by defining the MODBUS_PORT manifest constant to be 1 instead of 0. This can be done via the project properties (Properties > C/C++ Build > Settings > GNU C Compiler > Symbols), as shown in Figure 4-1, or the manifest constant can be modified as shown in Figure 4-2 by editing Modbus_MSS_MSS_CM3_0_app/demo/Microsemi Smart Fusion/demo.c.

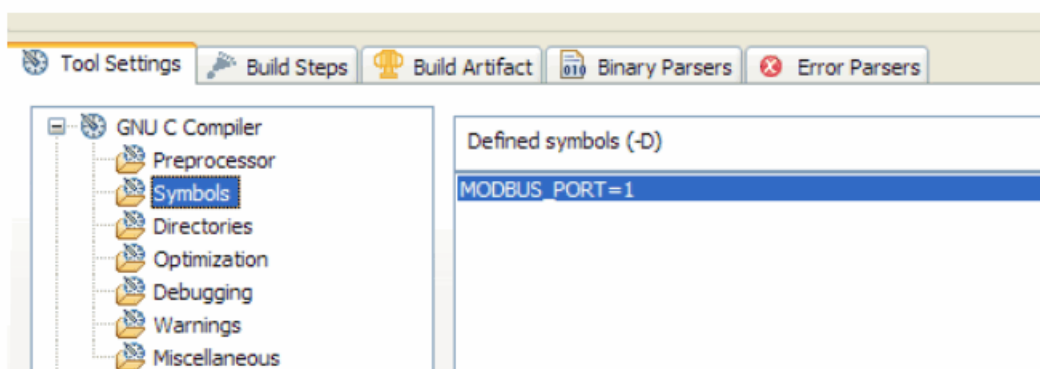


Figure 4-1 • Define MODBUS_PORT in Project Properties

```

47#define MODBUS_SLAVE_ADDR      0x1
48#endif
49
50#ifndef MODBUS_PORT
51/* Modbus serial port: 0 = MSS UART_0/RS-232, 1 = MSS UART_1/RS-485 */
52#define MODBUS_PORT              1
53#endif
54
55#ifndef MODBUS BAUD RATE

```

Figure 4-2 • Define MODBUS_PORT in demo.c

For RS-485 communications, an appropriate RS-485 based master and RS-485 A/B (also known as D+/D-) plus GND differential encoding twisted pair network cabling is required; optionally bus/multi-drop (multiple slaves connected to a single master) rather than point to point (master to single slave). See [Reference 4] and [Reference 10] for more details about RS-485 network cabling.

When using a PC hosted Modbus master to exercise the reference design slave, an RS-232 to RS-485 converter dongle is usually required since PCs normally do not come with an RS-485 port by default. Examples of such dongles used during the development of the reference design include these:

- DealExtreme.com: www.dealextreme.com/p/rs232-to-rs485-converter-6040
- FocalPrice.com:
www.focalprice.com/CN051B/Data_Communication_Product_RS232RS485_Converter_Black.html

When using Modbus over RS-485, appropriate and timely control of the transceiver's drive/receive enable signals for half duplex transmit/receive turnaround is critical. Refer to this Neutrino® article for some background on this in a general (non Modbus specific) context: www.neutrino.com/Embedded-Systems/How-To/RS-485-Transmit-Enable-Signal

In the reference design, the A2F500-DEV-KIT board's MAXIM MAX3430 RS-485 transceiver transmit/receive (DE/Ren –drive/receive enable) signals are managed by the firmware using the MSS UART_1 modem control RTSn (inverted) and Darin signals and the MSS Timer 2 is used to allow for settling time on these signals. The approach taken to transmit/receive turnaround management corresponds to option 5 in the Neutrino article.

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List of Changes

List of Changes

The following table lists critical changes that were made in each revision of the chapter.

Date	Changes	Page
Revision 3 (January 2013)	Added “Board Settings” section (SAR 43469).	8
Revision 2 (May 2012)	Modified “Installing the Reference Design” section (SAR 38392)	7
	Replaced Figure 1-1 (SAR 38392)	7
	Replaced the command in “Read Coils Registers” (SAR 38392)	13
	Modified Table 2-1 (SAR 38392)	20
Revision 1 (January 2012)	Modified the “Installing the Reference Design” section (SAR 36029).	7
	Modified the “Read Holding Registers” section (SAR 36029).	12
	Modified the “Using Automated Solution’s Mini HMI” section (SAR 36029).	13
	Modified the “Project Layout” section (SAR 36029).	19
	Modified the “Slave Firmware Configuration #defines” section (SAR 36029).	21
	Modified the “Linker Scripts” section (SAR 36029).	22
	Modified the text listed under “RS-485 Communications” section (SAR 36029).	27
	Changed all the references of Libero IDE to Libero SoC (SAR 36029).	

Note: *The part number is located on the last page of the document. The digits following the slash indicate the month and year of publication.

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Index

A add registers 24

C communication settings (default) 8 contacting Microsemi SoC Products Group customer service 33
email 33 web-based technical support 33 customer service 33

F features, reference design 5

I installation of reference design 7

L Libero IDE project MSS resources 25 linker scripts 22

M Microsemi SoC Products Group email 33 web-based technical support 33 website 33 Mini HMI 13 read discrete inputs and coils 17 read input registers 14 read/write holding registers 15 write coils 18 Modbus function codes supported 24 Modbus functions supported 5 Modbus registers 23

Modpoll 8 command line parameters 9 read coils registers 13 read holding registers 12 read input registers 14 read discrete input registers 10

O overview 5

P product support customer service 33 email 33 My Cases 34 outside the U.S. 34 technical support 33 website 33

R References 29 RS-485 communications 27

S Soft Console project default configuration 22 folder contents 20 Softconsole project #defines 21 Soft Console Project Explorer 19

T tech support ITAR 34 My Cases 34 outside the U.S. 34 technical support 33

W web-based technical support 33

Z zip file contents 7



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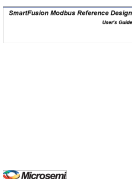
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